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ABSTRACT

A study was conducted to determine the degree of relationship between eye movement patterns and cognitive mapping as determined by the Cognitive Style Mapping Instrument (CSMI). It was hypothesized that a high correlation exists between a predominance of visual and auditory eye movement patterns and the visual and auditory cognitive mapping styles determined by the CSMI--visual language (VL), auditory language (AL), and auditory quantitative (AQ) scores. Subjects were 20 students, staff members, or alumni of a large southwestern university. Each completed the CSMI and an individual interview in which they were asked to perform a memorization task by means of a tape recorded message and a written handout. The results of a discriminant analysis procedure were significant at the .095 level of confidence. The findings indicated that AL was the best predictor of visual eye movements, and that the CSMI measured learning modalities the subject was aware of and could report on, whereas eye movements often measured what the subject was not consciously aware of--often different modalities. (Appendixes contain a discussion of information processing and cognitive style, the reading passage, and the instructions for the tape recorded message used in the study.) (Author/FL)

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AN INVESTIGATION OF EYE MOVEMENT PATTERNS IN RELATION TO COGNITIVE MAPPING STYLE

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Abstract

An Investigation of Eye Movement Patterns
In Relation To Cognitive Mapping Style

University of Houston

This study examined whether a relationship exists between preferred learning modality as determined by the Cognitive Style Mapping Instrument (CSMI) and learning modality as determined by observable eye movements. The CSMI yielded auditory language (AL), visual language (VL), and auditory quantitative (AQ) scores. The eye movement test consisted of a two part memorization task administered by two scorers during which eye movements were recorded and scored according to predominant modality, auditory or visual. The sample consisted of 20 students, staff, or alumni members of a large southwestern university: 9 males and 11 females. The results of a discriminant analysis procedure were significant at the .095 level of confidence. It was found that AL was the best predictor of visual eye movements and that the CSMI measured learning modalities the subject was aware of and could report, whereas eye movements often measured what the subject was not consciously aware of. These were often different modalities. Future research directed toward the question of the interaction between modalities and possible sequences of modalities used in learning was recommended.

An Investigation of Eye Movement Patterns

In Relation to Cognitive Mapping Style

University of Houston

Determining human information processing strategies has been the focal point of recent research in the field of cognitive psychology. The concept of cognitive mapping styles is being used in educational counseling to facilitate both teacher training and student placement. There are several methods of determining cognitive mapping styles. Hill's Cognitive Style Mapping Instrument (CSMI) was developed for use at the college level to identify several aspects of cognitive style, including the predominance of auditory or visual learning preferences. Another method of determining auditory or visual information processing has been described by Grinder, Bandler, and DeLozier (1975), Bandler and Grinder (1979), and Cameron-Bandler (1978) in their work in modeling and training psychotherapists. They observe eye movement patterns which cue accessing of the learning modalities.

Although relatively little has been done to support the notion that eye movements also cue internal image processing, a great deal of research has been done on eye scanning movements for external images (Dimond, 1974). Trevarthen (1974, 244) describes the relation of eye scanning to the perception of an external visual field. Even so-called voluntary eye

movements are described as being unconscious. Tests of ambient vision showed that various stimuli in motion are perceived in one unified configuration. As the eye scans an object, the individual is not aware of displacements in the retinal image. Nor is he/she aware of the gaps in visual information actually being received. Trevarthen (1974, 244-245) states:

> What we see is thus a result of combining imagined and remembered details with brief samples of optic information to synthesise a stable space with objects in it. Colour and form information is incorporated into percepts actively according to their already integrated structure, and with reference to the particular objects of conscious interest at the moment.

Douglas Clovis Hall (1972) investigated whether a functional relationship between eye movements and internal visualization could be observed. He found that eye movements are a necessary functional component of imaged recall information in certain contexts, and that in fact, inappropriate movements actually disrupted the process of imagining spacial organization. He also concluded that the role of eye movements in internal visual imagery is analogous to eye scanning in external perception and that imagery and perception are both phenomena along a single continuum of experience. Thus internal and external visualization, or a visual lead or visual input, would be linked to observable eye movements. Since according to Trevarthen

(1974, 245), even external visual images are part imagination and memory by the time they are received by the brain, it is not surprising that Hall should find this similarity between eye movements for external and internal images.

Seaman (1974, 200) describes the notion of separate information processing systems for verbal and visual information based on left-right hemispheric function, presenting data which indicates that subjects are able to generate a visual representation of an auditory stimulus and an auditory representation of a visual one. If this is so, it might not be surprising that eye movements for an auditory image (A) would be just as necessary for (A) internal recall as they are for visual recall. In other words, if people move their eyes to make pictures, perhaps they do the same to hear sounds, feel feelings, and so on.

Purpose

The purpose of this study is to determine the degree of relationship between eye movement patterns and cognitive style mapping as determined by Hill's Cognitive Style Mapping Instrument. It is hypotnesized that a high correlation exists between a predominance of visual and auditory eye movement patterns as defined by Grinder et al. and the visual and auditory cognitive mapping styles determined by the CSMI: visual language (VL), auditory language (AL),

and auditory quantitative (AQ).

The system of observable eye movement patterns used as a practical construct by Grinder et al. in teaching psychotherapists to deal with their clients' processing strategies might have an enormous importance in the field of education as an adjunct to the practical application of cognitive style mapping. The ability to infer students' processing strategies from observation of eye movements would enable teachers to structure material in ways appropriate to the individual learner.

Sample

The sample consisted of 20 subjects, 9 males and 11 females, who were students, staff, or alumni members of a large southwestern university.

Instrumentation

The Cognitive Style Mapping Instrument (Hill, 1970) is a 184 item self-report inventory employing a Likert scaling procedure which indicates how an individual prefers to access information, how he relates to others, and what type of reasoning he prefers. Validity coefficients presented by Hill (Molina, 1976, 32) for the preferences of information presentation (visual, auditory, symbolic) range from .72 to .80. Reliability coefficients range from .87

to .93.

The CSMI used in this study is a modified form of the original instrument used by Oakland Community College in Bloomfield Hills, Michigan. The instrument, both original and modified versions, is edumetric rather than psychometric.[1]

Cogan (1976, 13-14) reports an investigation of the validity and reliability of the modified CSMI which was conducted in 1974 with a group of 71 speech communication students. Gains in skills related to their course were compared to changes in the CSMI. The internal validity of over 94% of the items was significant at the .05 level and all of the elements were significant at the same level. The external validity of five of the elements was studied by comparing a speech communication skill with changes in the CSMI. Two of these had external validity coefficients significant at the .05 level.

For reliability and validity, a correlation of .235 (df=69) was significant at the .05 level. Twenty out of 27 KR-20 correlations were significant at the .05 level, and 22 out of 27 split-half reliability coefficients were

[1]Edumetric tests are defined as those which "measure the gain or growth of an individual's knowledge, learning skills, or abilities, and are concerned with the difference within an individual" (Cogan, 1976, 43). Psychometric tests are defined as those that "measure individual differences in relationship to a group and are reliable and valid in terms of how they reflect the consistencies between individual differences" (Cogan, 1976, 3).

also significant at the .05 level. Cogan (1976, 14) states that "the modified CSMI instrument was determined to be very reliable and some evidence for edumetric validity was found."

Method

The subjects' cognitive styles were assessed using a modified form of the CSMI. Each subject was also given an individual interview in which he or she was observed performing a memorization task by means of a tape recorded message and a written handout. The task was designed to include both auditory and visual components which could be observed separately. After a time limit, the subject was asked to repeat to the experimenters the information that had just been learned. As he or she accessed this information while speaking, two experimenters observed and recorded the predominant position of eye movements for the individual.[2] Subjects who appeared to use sequences of modalities instead of one primary modality on the eye movement test were not included in the analysis of the data. Out of 20 subjects included in the analysis, 12 were assessed as having predominantly auditory

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[2]This study would not have been possible without the help of many individuals whose assistance is hereby gratefully acknowledged. Special thanks to Valdemar G. Phoenix for his help in conducting and scoring the eye movement interviews.

eye movements, and 8 as having predominantly visual.

Data Analysis

Pearson product-moment correlation among the variables were found, and the Statistical Package for the Social Sciences (SPSS) (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975) was used for analysis of the data with a two-group discriminant analysis procedure.

Insert Table 1 near here

Auditory language (AL), auditory quantitative (AQ), and visual language (VL) variables on the CSMI discriminated the two groups: auditory and visual on the eye movement test ($p < .095$). AL scores yielded a coefficient of .87, AQ scores a coefficient of -.57, and VL scores a coefficient of .85. Subjects who were rated as auditory learners on the eye movement test showed low AL and VL scores and high AQ scores on the CSMI. Subjects who were rated as visual learners on the eye movement test showed high AL and VL scores and low AQ scores on the CSMI (p .095). Actual mean

scores were higher for visual than for auditory subjects.

Some unexpected trends in the data were noted: visual (eye movement) learners scored higher means on both language sections of the CSMI (AL and VL), and auditory learners scored higher on both quantitative (AQ and VQ) sections. It had been expected that visual (eye movement) learners would score higher on VL and VQ and that auditory learners would score higher on AL and AQ. The test items' being divided into either language or quantitative sections proved

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Insert Table 2 near here

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to be a better predictor of eye movement patterns than whether the items purported to measure auditory or visual cognitive style. In Table 2 Wilk's lambda for AL and VL was .9363 and .9391, respectively, showing that those variables were the best predictors of eye movements, which in this case were visual for both. The smaller number of visual (8) to auditory (12) subjects assessed on the eye movement test could have caused the means to be inflated, however.

Discussion

Although the data here are not conclusive, they do indicate some difficulties in the assessment of cognitive

style. Thomason, Arbuckle, and Cady (1980) found that questions trying to evoke certain sensory modalities did not significantly influence eye movement patterns. However, they did find that the eye movements were mostly visual for questions in all modalities tested (image, sound, or tactile sensation).[2] These results parallel those on the language items of the CSMI, which also invoked mostly visual eye movements. Perhaps a person's preferred learning modality (in this case, visual) would be used regardless of the type of language used by a testing instrument. Also, for a population of university affiliated subjects, a higher instance of visual processing might occur due to the nature of academic work.

An examination of the wording of the language (AL and VL) items from the modified CSMI reveals a further possibility. Out of eight items on the two sections, not one is immune to the possibility that a subject could use the item as a stimulus for visualization. The AL section, intended to assess the derivation of meaning from the spoken word, might attract affirmative responses not only from truly auditory subjects, but also from facile visualizers who make internal pictures

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[2] Evidence for a visual dominance effect was also reported by Lange (1980) in a study designed to test the validity of the construct of Bandler and Grinder's "representational system". 92% of all verbal responses to an audio-visual presentation of letters, numbers, and words, were visual.

while listening to the spoken word. The VL section could attract high affirmative responses from truly visual subjects and perhaps also from auditory subjects who, lacking in internal visual ability, would use the external visual stimulus as a prop. The hemispheric specialization of the human brain would allow an overlap of functions located in different hemispheres, but not in the same hemisphere. Thus auditory and visual might be used on the same task nearly simultaneously, but visual external and visual internal processing would not be.

Visual eye movement subjects had higher mean scores on both AL and VL, indicating that both sections may be good predictors of visual cognitive style. AL involves the "spoken word" and thus might invite <u>internal</u> visualization. VL assesses gaining meaning through the "written word" and so would invite <u>external</u> visualization. Among visualizers, then, there may exist both internal and external visualizers. These would be different processes (see appendix, "lead system" and representational system").[3]

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[3] Owens (1977) found that the modality most frequently used in subjects' verbalizations correlated significantly ($p<.05$) with eye movements. This was more reliable than pairing self-report with either eye movement or verbalization. This lends support to the notion that individuals cannot accurately indicate through written testing that which they are doing unconsciously, i.e. moving their eyes. It also supports the notion that internal processing may be done in a different modality than that used in external processing.

On the CSMI, items on AL and VL exclude an affirmative answer on both. This supports the possibility of external and internal processing. (Example: AL "I prefer to follow spoken directions rather than written ones." and VL "I would rather read directions than hear someone tell them to me.") The same is true of AQ and VQ - a subject answering affirmatively on one section would have to answer negatively on the other. Yet visual subjects scored higher means on both AL and VL, and auditory subjects scored higher on both AQ and VQ, possibly indicating that there are different types of visual and auditory learners.

In Table 2 the language sections of the CSMI, AL and VL, proved to be better predictors of eye movement patterns than did the quantitative sections, AQ and VQ. It should be noted that the nature of the memorization passage in the eye movement test was verbal rather than mathematical and that the experiment was designed to assess cognitive style in nonmathematical, lecture type or reading situations. It might be expected, therefore, that the quantitative section of the CSMI would not measure the same skills assessed on the eye movement test.

Conclusion

This data indicates the complexity of measuring a construct as elusive as cognitive style. The label "visual learner" or "auditory learner" may be incomplete. In order to effectively determine a person's cognitive style, it might be necessary to

consider whether the preference is visual or auditory, external or internal. It might also be useful to designate cognitive style preferences according to tasks (i.e. language or quantitative) as the CSMI does. A written test or eye movement observations alone may not be able to do this. Perhaps a combination of written testing and observation of both eye movements and verbalizations would facilitate a more accurate assessment than either procedure alone.

Implications

This study pointed to a need for research to determine whether a difference exists between preferred internal and external use of modalities. It may be that the preferred external modality in some cases matches the internal. But in other cases the external may complement or compensate for the internal, in which case, the external would actually be the weaker modality. Visual learners, for example, might need visual props precisely because their visualization skills were so weak. The visual modality would show as a strength on cognitive mapping tests yet would not be usable as an internal resource. The data collected for this project indicated that cognitive style mapping for modalities is complex - not only are there auditory and visual learners, but it seems that some subjects use a sequence of the two. It is recommended

that future research be directed toward the question of the interaction between modalities and possible sequences of modalities used in learning.

TABLE 1

Standardized Discriminant
Function Coefficients

	Function 1
A1	0.86977
AQ	-0.57485
VL	0.85387

Centroids of Groups
in Reduced Space

	Function 1
Group 0 (Auditory)	-0.45031
Group 1 (Visual)	0.67547

TABLE 2

MEANS

	Auditory	Visual
AL	23.1667	26.2500
AQ	20.8333	17.7500
VL	27.0000	30.5000
VQ	33.0000	32.0000

WILKS' LAMBDA

AL	0.9363
AQ	0.9444
VL	0.9391
VQ	0.9917

APPENDIX

Information Processing and Cognitive Style

In psychology, cognitive style has traditionally been defined as information processing habits that represent typical modes of perceiving, thinking, remembering, and problem solving (Martens, 1975, 3). Joseph E. Hill departs from this traditional definition, however, preferring to define cognitive style as the way in which an individual takes meaning from his environment. According to Hill, it involves the Cartesian product of four sets: (1) symbols and their meaning, (2) cultural determinants, (3) modalities of inference, and (4) memory-concern (Martens, 1975, 3). He believes that cognitive style is not fixed, but can be changed by training. This study deals only with the third and fourth of these sets: modalities and memory, and, more specifically, with the visual and auditory modalities.

Grinder et al. use another model to describe several aspects of human information processing. A person can be aware of only a certain portion of his experience at any given time. This awareness is patterned according to the channels of sensory awareness: auditory, visual, kinesthetic, and olfactory. This model is called the 4-tuple model and is represented as (A,V,K,O). Awareness of an experience at a given moment may be limited to any one of these: (A), (V),

(K), or (O). Or it may progress rapidly in a sequence through several channels: O--V--A--K. This processing strategy, or use of several channels in a sequence, is task specific and highly individualized. Hundreds of different combinations are possible, but it seems that individuals prefer certain strategies over others.

The directionality of the information being processed is considered in four ways. First of all, there is the preferred input channel. An individual might use (A) tonal to input music, (V) art, or (O) the experience of a rose. In the case of academic information, some students will prefer (A) digital, some (V), and some even (K). In theory, the input channels (A) and (V) may be analogous to the cognitive mapping styles, auditory and visual.

Secondly, there is the output channel, which is simply the mode of external communication chosen in a given situation. Thirdly, there is the preferred lead system, which is the internal accessing of stored information or the internal construction of new patterns. The lead system is used whenever the individual wants to access visual, auditory, kinesthetic, or olfactory images or create new images. This is an internal process unique to each person.

Often internal strategies are used sequentially if the complete task requires more than one channel. For example, someone who is trying to remember the fragrance of a rose might not be able to access (O) directly but might have to

begin by making a picture (visual lead) of a large colorful rose. After that it would be possible to access the fragrance. This strategy would be represented V--O. In theory, the lead systems (A) and (V) may also be analogous to the cognitive mapping styles, auditory and visual. Both lead and input channels are used to access information, the first being internal and the second external. The concept of modalities in cognitive mapping style does not seem to make that distinction.

Fourth, there is the representational system, which is the way in which the individual represents the information after it has been accessed. One of the elements of the 4-tuple will become the system most characteristic of the individual's personal way of dealing with the world. This system will be a preferred mode of acting upon internal and external perceptions once they have been accessed through input and lead systems.

One proposed method of determining the lead and input channels being used at a given time by a particular individual is by observing his/her eye movement patterns. Grinder et al. teach that eye movements are a necessary neurological correlate of accessing in a preferred modality. They derived this system from their own observations (John Grinder, Personal communication, Nov. 1979). In a typical right handed individual, facing him/her, eyes up or unfocused indicates visualization. Eyes up to the left shows constructed visual imagery; eyes up

to the right shows eidetic or remembered visual imagery. Eyes down/right indicates auditory images, either auditory digital or tonal. Eyes centered shifting left and right also indicates auditory processing. Finally, eyes down/left indicates kinesthetic accessing. The kinesthetic modality here includes feeling states, and tactile, gustatory, and olfactory perceptions. Exceptions to this general schema include a left handed individual who may or may not have these patterns in the reverse order, depending on hemispheric dominance which varies for left handers (Dimond, 1974). And because of other individual differences in laterization, some very rare individuals may exhibit other distinct patterns.

Tape Recorded Instructions

Please listen carefully to the following instructions because you will be asked to repeat them back as closely as possible. You are going to be given a written passage to read and memorize. The passage is a story of medium difficulty written in a format common to many folktales and has elements of style which may or may not be familiar to you. Try to learn the passage in whatever way is most convenient for you, and you need to do this rapidly because you will be given only three minutes to complete the task. Now, would you repeat to the experimenter, as accurately as possible, what you remember of these instructions.

Reading Passage

Once upon a time in a far away land in a distant time there lived a good and simple people ruled by a wise and provident king. The kingdom was bounded on the west by the sea, on the east by a range of snow capped misty mountains, on the south by a desert, and on the north by fields of ice. The land was lush and filled with good things. The people lived in peace with all their neighbors. Only one thing disturbed the tranquility of this peaceful land -- a fiery and terrible monster who flew down from his lair in the mountains to devastate the fields and storm the castle of the king.

The people were terrified though he seldom harmed any of them directly. The economic situation of the kingdom had begun to deteriorate because the various commodities usually traded with neighboring countries were destroyed by the creature. Finally the king's son, the prince, called together a council of elders, ministers, statesmen, and warriors, 75 in number, and said to them: "My loyal and faithful subjects, our beloved kingdom lies in the gravest danger. We are confronted with perils that would destroy the future prosperity of our good people. I have brought you together to propose a way in which to free ourselves of this danger which so threatens us."

And so the prince proposed his plan while the council waited eagerly with growing astonishment at his wisdom.

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